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The Application Of Clay- Based Equation In Estimating Saturated Hydraulic Conductivity (K_s) Of Soils In Different Landuses Of Biase Rural Watershed,Cross River State-Nigeria

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Abstract: *This study assessed the extent of clay deposits in soil pores of different landuses arising from the sweeping action of surface erosion in rural watershed of Biase, Cross River State of Nigeria. The accumulation of clay particles in soil layer has the potential of lowering the infiltration rate of soils with threats on overland flow, water logging, erosion and general decline in regional land productivity. The clay based equation, developed by William, Jones and Dyke (1984) was used to evaluates soil saturated hydraulic conductivity (Ksat) as a measure of the relationship between the effects of clay deposits in soil layers and soil permeability during storm. Soil samples were taken at depths of between 0-30cm across landuses for laboratory analysis to establish percentage deposits of clay. The values of infiltration data were also used in the estimation process. The result showed the Ksat values of 4.9 and 0.96 (fallowland), 2.4 and 0.89 (floodplain) and 9.0 and 1.3 (forest). This indicate moderate deposits of clay colloidal materials in soil layers at the moment though not devoid of future threat especially in rural landuse practices replete with crude farming practices (slash and burn agriculture). Sustainable land management should be evolved to avert this threat.*

Keywords:*Clay deposits, saturated hydraulic conductivity, clay based equation, Infiltration data.*

I. Introduction

Saturated hydraulic conductivity (Ksat) describes the movement of water through a saturated or wet media. As a phenomenon, it relates to the property of vascular plants, soils and rocks that explains the ease with which a fluid (usually water) can move through pore spaces or fracture under saturated condition. This is turn depends on the intrinsic permeability of the material the degree of saturation, and also the density and viscousity of the fluid (Wosten, Pachepsky and Rawls, 2001).

Empirical studies showed that there is a relationship between hydraulic conductivity and soil physical properties such as pore size, particle size (grain size) distributions and soil texture (Antigha, 2007, Agnihori and Yadar, 2002). For a given soil, the effects of the inherent characteristics of soil are reflected in the saturated hydraulic conductivity (K_s), while that of land use by the infiltration capacity of soils under such land uses.

The clay based equation developed by William, Jones and Dyke (1984) otherwise called the component method of the EPIC (erosion induced productivity loss index calculator) finds relevant application in erosion prone regions of the tropics (Biase inclusive) where unsustainable land use practices are in vogue. A scientific assessment of this nature is apt to provide the percentage deposits of clay contents in soil layers since clay forms in-wash or colloid that has the potential of suppressing the infiltration capacity of soils during storm thereby encouraging runoff, erosion, landslide and related ecological events commonly experienced in this region.

The clay based equation is given thus:

$$K_s = \frac{12.7(100\text{-CLA})}{100\text{-CLA}+A \exp (11.45\text{-}0.097)(100\text{-CLA})} + 0.2$$

In which K_s is the saturated hydraulic conductivity (mm^{-1}) and CLA is the percentage clay in the soil layers.

An understanding of the moisture regime of soils using clay base equation is crucial in land use planning mostly in the construction and agro-allied industries, in order to ascertain the suitability of land environment for various developmental activities and hence the need for this study. Investigation was restricted to soils of fallow-land, flood plain and forest land uses.

Study area

The study area is Biase, comprising locations within Abini rural watershed. The area lies between longitude $8^0 06$ and $8^0 11$E and latitudes $5^0 00$N and $5^0 38$N its geological landform, falls within the Precambrian

Basement complex of Oban massif of southern Nigeria, overlain by cretaceous and tertiary sediments of the Calabar flank (Ekwueme, 2004). The lithological formation compose of phyillites, schists with structural features as foliation, joints, fold intrusion, pegmatite and barite. Such rock materials weather easily during storm to release fine clay minerals that clog soil pores to reduce the infiltration capacity of soils and inhibit saturated hydraulic conductivity of soils. Found in the humid tropics, the area has a distinct wet and dry seasons with rainfall amount ranging from 3,500 to 4,000mm per annum. It has a relative humidity of between 80 and 90 per cent. The temperature records annual mean of between 27^0c and 33^0c (Ayoade, 2004). The soil type derived mostly from cretaccous sediments of Eze-Aku group (Amajor, 1978). Formed under distinctive climatic conditions in the tropics, the soil types result from the total decomposition and alteration of rocks leading to the concentration of iron and aluminum (sexquiese) oxides and hydrides. Numerous hard and soft species of wood such as mahogany Iroko, Obeche, parasitic epiphytic, saprophytic/climbers and secondary vegetations dominate the area. Human activities are peasant agriculture based, impacting the regional ecosystems negatively.

II. Method Of Study

Estimating the saturated hydraulic conductivity of soils requires hydrologic investigation of soils from infiltration data and the laboratory determination of the physical properties of such soils which include textural characteristics of sand, silt and clay. Thus, a spade was used to excavate soils in different land uses of fallow-land, floodplain and forest to a depth of 30cm. the soil samples were labeled and bagged and taken to laboratory for analysis. This was done to determine the percentage deposits of clay in soil layers facilitated by surface rain wash and clay particle migration as “fines” into the soil layer likely to block pore spaces and decrease water permeability down the profile.

The model emphasizes the use of clay values from laboratory results for application into the equation to aid isolation process of the effect of land use on clay deposits in soil layers which correlated the observed values of equilibrium infiltration rate of soils in different land uses. This study adopted a similar empirical approach to yield useful results from this research endeavor.

III. Results And Discussion

Table 1:Soil physical properties of different landuses

Landuse type	Sand %	Silt %	Clay %	Texture
Fallowland	67	19	14	Sl
Floodplain	68	17	15	Sl
Forest	68	25	7	Scl

Sl: Sandy loam, Scl: Sandy clay loam
Source: Authors’fieldwork(2014)

Table 1 shows the percentage composition of the various soil separates (sand, silt, clay) in fallow land, flood plain and forest land uses. From the table, sand, silt and clay content of fallow land is 67, 19 and 14 per cent. In that order, that of floodplain remains 68, 17 and 15 per cent respectively while forest has values of 68, 25 and 7 per cent. Also, while the textural class for fallow land and flood plain indicate sandy loam, that of forest has a slight variation of sandy clay loam.

Table 2: Saturated hydraulic conductivity of soils under different landuses

Landuse type	Soil depth	Clay in soil layers	K_s mm/hr in soil layers	Cm/hr in soil layers	Mean infiltration	Soil permeability range
Fallow land	0-15cm	14.0	9.58	0.96	4.9	0.6-20
	15-30cm	14.3	9.55	0.96		
Floodplain	0-15cm	15.0	8.94	0.89		
	15-30cm	14.6	8.69	0.87	2.4	0.6020
Forest	0-15cm	7.0	10.32	1.32	9.0	0.6-20
	15-30cm	7.14	9.79	0.98		

Source: Authors’ fieldwork, 2014.

Table 2, reveals the relationship between infiltration rate and hydraulic conductivity as explained by the values of 4.9 and 0.96 (fallowland), 2.4 and 0.89 (floodplain) and 9.0 and 1.3 (forest). Spatially, the Ks values of clay from 0-30cm show little variation due to the structural stability of soils. Results also indicate the presence of fine textured clay in soils of land uses. Although, there were slight variations in clay content according to successive soil layers, the final Ks values computed did not significantly alter values within soil permeability range. This suggests homogeneity in textural characteristics and water holding capacity of soils. According to Bonsu (2002) sufficient clay content in soil enhances soil cohesion and decrease in its shearing propensity. The soils also showed moderate permeability and low hydraulic conductivity. Under natural conditions, such soils are less prone to leaching, runoff and erosion. But uncontrollable removal of vegetal cover by humans accelerates the washing away of clay content thereby encouraging the shearing phenomenon of affected soils.

IV. Conclusion

The clay based equation used in determining the relationship between soil permeability and hydraulic conductivity revealed the stabilizing effects of clay particles in soil layers. However, accelerated movement of fine clay particles down the profile is inevitable under crude farming practices. Consequently, other factors as slope, rainfall forest clearance, poor tillage and related cultural practices not explained by this model, combined to pose serious threats to the occurrence of runoff, landslide and erosion events in future of unless sustainable land use practices are evolved through public enlightenment.

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